

## CLAIMS

What I claim is:

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1. A multiple chamber airbag cushion having at least one material component, at least two chambers, and

wherein said airbag cushion possesses an effective material usage factor of less than about 0.095.

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2. The airbag cushion of Claim 1, wherein said airbag cushion possesses an effective material usage factor of less than about 0.09.

3. The airbag cushion of Claim 2, wherein said airbag cushion possesses an effective material usage factor of less than about 0.085.

4. The airbag cushion of Claim 3, wherein said airbag cushion possesses an effective material usage factor of less than about 0.08.

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5. The airbag cushion of Claim 4, wherein said airbag cushion possesses and effective material usage factor of less than about 0.075.

6. The airbag cushion of claim 5, wherein said airbag cushion is a two-chamber tethered airbag cushion.

7. The airbag cushion of claim 1, wherein said airbag cushion is constructed of fabric and has a fabric usage factor of less than about 0.095.

5           8. A multiple chamber airbag cushion having at least one material component, and wherein said airbag cushion is formed using less than 5.00 square meters of material.

10           9. The airbag cushion of Claim 8, wherein said airbag cushion is formed using less than 4.0 square meters of material.

15           10. The airbag cushion of Claim 9, wherein said airbag cushion is formed using less than 3.0 square meters of material.

20           11. The airbag cushion of Claim 10, wherein said airbag cushion is formed using less than 2.0 square meters of material.

            12. The airbag cushion of Claim 11, wherein said airbag cushion is formed using less than 1.0 square meter of material.

            13. The airbag cushion of Claim 12, wherein said airbag cushion is a two chamber tethered airbag cushion.

14. The airbag cushion of claim 8, wherein said material is at least one of coated and uncoated fabric.

5 15. In an airbag cushion filled by gas during inflation, having at least first and second panels connected by edge seams and forming a primary chamber, the improvement comprising a secondary chamber being formed by an additional panel attached to a central portion of the second panel, and at least one vent hole in one of the second panel and additional panel to provide for gas to fill the secondary chamber after  
10 the filling of the primary chamber during inflation.

16. The airbag cushion as recited in claim 15, wherein the third panel is attached over at least a central portion of the outer surface of the second panel, and at least one vent hole in the second panel in a position located under said third panel.

15 17. The airbag cushion as recited in Claim 15, further comprising tethers between said first and second panels, located near the center of said second panel, and forming a concave area in said second panel, below said third panel, when the airbag cushion is inflated.

20 18. The airbag cushion as recited in claim 15, wherein at least said first and second panels are at least one of coated and uncoated fabric.

19. The airbag cushion as recited in claim 15, wherein all of said panels are at least one of coated and uncoated fabric.

5 20. The airbag cushion as recited in claim 17, wherein all of said panels and said tethers are at least one of coated and uncoated fabric.

21. A multiple chamber airbag cushion comprising:

a first panel having a central gas opening and at least one vent hole,

10 a second panel having substantially the same dimensions as the first panel, having at least one vent opening spaced from the center thereof, and being attached to the first panel, along the edge thereof,

15 a third panel having dimensions less than or equal to that of the second panel, having no vent openings therein, and being attached along the edge thereof to the second panel in a position covering the at least one vent opening in said second panel, and at least one tether attached between said first and second panels near the center thereof and having at least one vent opening in the side thereof to provide for the flow of gas from the gas opening in said first panel into a primary chamber defined between said first and second panels and, a secondary chamber defined between said second and third  
20 panels receives gas from said primary chamber through said at least one vent opening in said second panel.

22. The multiple chamber airbag cushion as recited in Claim 21, wherein said first, second and third panels are at least one of circular, polygon-shaped, or combinations thereof.

5 23. The multiple chamber airbag cushion as recited in Claim 21, wherein said third panel has smaller dimensions than said second panel.

24. The multiple chamber airbag cushion as recited in Claim 21, wherein said second panel includes at least two spaced vent openings.

25. The multiple chamber airbag cushion as recited in Claim 21, wherein at least one of said panels has tucked pleats to form a three dimensional shape.

26. The multiple chamber airbag cushion as recited in Claim 21, having enhanced  
15 safety performance characteristics since said primary chamber fills more quickly than said secondary chamber.

27. The multiple chamber airbag cushion as recited in Claim 21, wherein a plurality of tethers form a first chamber within said primary chamber which receives gas  
20 through said gas opening in said first panel and vents to a second chamber of said primary chamber.

28. The multiple chamber airbag cushion as recited in Claim 21, wherein said at least one vent opening in said second panel is located adjacent the location of attachment of said at least one tether to said second panel.

5 29. The multiple chamber airbag cushion as recited in Claim 21, wherein the length of said at least one tether is selected to form a concave area in the center of the face of said second panel upon inflation of the airbag cushion.

10 30. The multiple chamber airbag cushion as recited in Claim 21, wherein said airbag cushion is constructed by simple sewing steps of attaching said at least one tether to said first and second panels, attaching said third panel to said second panel, and then attaching said first panel to said second panel.

15 31. The multiple chamber airbag cushion as recited in Claim 21, wherein said secondary chamber has a smaller volume than said primary chamber.

32. The multiple chamber airbag cushion as recited in Claim 21, wherein said airbag cushion is at least one of a driver side airbag cushion, passenger side airbag cushion, side airbag cushion, and side curtain airbag cushion.

20 33. The multiple chamber airbag cushion as recited in Claim 21, wherein said third panel is made of single ply fabric.

34. The multiple chamber airbag cushion as recited in claim 21, wherein said third panel is made of a soft, low abrasion material.

5 35. The multiple chamber airbag cushion as recited in claim 21, wherein said first, second and third panels are fabric, and said third panel is made of a fabric which is at least one of lighter, softer and less abrasive than the fabric of said first and second panels.

10 36. The multiple chamber airbag cushion as recited in Claim 21, wherein said second panel is formed of uncoated fabric.

15 37. The multiple chamber airbag cushion as recited in Claim 21, wherein said first and third panels are formed of coated fabric.

38. The multiple chamber airbag cushion as recited in Claim 21, wherein the length of the tether is shorter than the tether in a single chamber tethered airbag.

20 39. The multiple chamber airbag cushion as recited in Claim 21, wherein the length of said at least one tether is less than about 350 mm.

40. The multiple chamber airbag cushion as recited in Claim 39, wherein the length of the tether is less than about 300 mm.

41. The multiple chamber airbag cushion as recited in Claim 21, wherein the at least one tether is attached to said second panel by a circular stitch having a diameter of at least 3 inches.

42. The multiple chamber airbag cushion as recited in Claim 41, wherein the diameter of said circular stitch is about 4 to 5 inches.

43. The multiple chamber airbag cushion as recited in Claim 21, wherein said at least one tether is formed of uncoated fabric.

44. The multiple chamber airbag cushion as recited in Claim 21, wherein said at least one tether serves as a gas regulator.

45. The multiple chamber airbag cushion as recited in Claim 21, wherein additional tethers are used to control the excursion of at least one of the primary and secondary chambers.

46. The multiple chamber airbag cushion as recited in Claim 21, further comprising a fourth panel secured to said second panel over said third panel, and wherein



at least one of said second and third panels includes a vent opening providing for inflation of a tertiary chamber defined between said fourth panel and said second and third panels.

5           47. The multiple chamber airbag cushion as recited in Claim 46, wherein said fourth panel is larger than said third panel.

10           48. The multiple chamber airbag cushion as recited in Claim 46, wherein said panels are attached to one another and said tethers are attached to said panels by simple sewing.

15           49. The multiple chamber airbag cushion as recited in Claim 21, wherein said at least one tether includes at least two tether elements which are attached one to another.

20           50. The multiple chamber airbag as recited in claim 49, wherein one tether element is cut at a 45° bias to the warp and fill and the other tether element is cut at 90°.

          51. The multiple chamber airbag cushion as recited in Claim 49, wherein said tether elements are attached to said first and second panels by a circular stitching pattern.

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          52. The multiple chamber airbag cushion as recited in Claim 21, wherein said

airbag cushion includes a plurality of tethers and wherein each said tether is formed of at least two parts each joined one to another along their ends substantially midway between said first and second panels.

5           53. The multiple chamber airbag cushion as recited in Claim 21, wherein the secondary chamber receives and is filled by gas that has passed through the primary chamber upon inflation of the cushion.

10           54. The multiple chamber airbag cushion as recited in claim 21, wherein said at least one tether has a width of at least 3 inches.

15           55. The multiple chamber airbag cushion of Claim 21, wherein the size of the at least one opening vent holes in the second panel is selected to provide for a fill rate of said secondary chamber of less than that of the primary chamber.

          56. The multiple chamber airbag cushion of claim 55, wherein there are at least two vent openings in said second panel and each opening is at least ½ inch in diameter.

20           57. The multiple chamber airbag cushion of Claim 21, wherein said at least one vent opening in said second panel are offset from corresponding vent holes in the tether to provide a gas regulation effect of between the two chambers.

58. The multiple chamber airbag cushion of Claim 57, wherein the vent holes in at least one of said second panel and tether include elongate slits extending therefrom to provide for enlargement of said vent holes upon inflation of said cushion.

5 59. The multiple chamber airbag cushion as recited in Claim 21, wherein the filled volume of said primary chamber is greater than the filled volume of said secondary chamber.

10 60. The multiple chamber airbag cushion of claim 59, wherein the filled volume of the primary chamber is about 80 to 100 liters and the filled volume of the secondary chamber is about 30 to 50 liters.

15 61. The multiple chamber airbag cushion of claim 60, wherein the airbag cushion is a passenger side airbag cushion.

62. The multiple chamber airbag cushion of Claim 59, wherein the primary chamber has a filled volume of about 38 liters and said secondary chamber has a filled volume of about 12 liters.

20 63. The multiple chamber airbag cushion of Claim 21, wherein the fill volume ratio of said secondary chamber to said primary chamber is at most 1/1.

64. The multiple chamber airbag cushion of Claim 63, wherein the fill volume ratio of said secondary chamber to said primary chamber is at most  $2/3$ .

65. The multiple chamber airbag cushion of Claim 63, wherein the fill volume ratio of said secondary chamber to said primary chamber is at most  $1/3$ .

66. The multiple chamber airbag cushion of Claim 46, wherein the fill volume of said primary chamber is greater than that of said secondary chamber, and said fill volume of said tertiary chamber is greater than that of said secondary chamber.

67. A multiple chamber airbag cushion having enhanced safety characteristics as compared to a conventional single chamber airbag, including at least one of reduced impact, reduced rebound, smaller size, reduced possible injury to out of position occupant, faster gas fill to the primary chamber, slower gas fill to the secondary chamber, smaller dimension of the primary chamber, smaller dimension of the secondary chamber, a softer fabric over in the secondary chamber, a lower pressure in the secondary chamber, and combinations thereof.

68. The multiple chamber airbag cushion as recited in Claim 29, wherein each of said tethers has an enlarged substantially elongated oval central region and wherein the respective central region of each tether is adapted to be attached to the respective first and second panels.

69. A method of constructing a multiple chamber airbag cushion including at least first, second, and third body panels and at least one tether, and having at least primary and secondary inflatable chambers, comprising the steps of attaching at least one tether to  
5 each of said first and second panels, attaching said third panel to said second panel, attaching, said first and second panels together, and then attaching the tethers one to another.

70. In a vehicle occupant restraint system, the improvement comprising a  
10 multiple chamber airbag cushion as recited in Claim 21.

71. An airbag cushion fabric layout including respective fabric parts for at least two multiple chamber airbag cushions and using less than 5.0 square meters of fabric per bag.  
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72. The airbag cushion of claim 15, wherein said first and second panels are attached to one another by rip stitches.

73. A multiple chamber driver side airbag cushion comprising:

- 20 a first panel having a central gas opening and at least one vent hole,  
a second panel having substantially the same dimensions as the first panel,

having at least one vent opening spaced from the center thereof, and being attached to the first panel, along the edge thereof,

a third panel having dimensions less than or equal to that of the second panel, and being attached along the edge thereof to the second panel in a position  
5 covering the at least one vent opening in said second panel,

and at least one tether attached between said first and second panels near the center thereof and having at least one event opening in the side thereof to provide for the flow of gas from the gas opening in said first panel into a primary chamber defined between said first and second panels, a secondary chamber defined between said second  
10 and third panels receives gas from said primary chamber through said at least one vent opening in said second panel.

74. A multiple chamber passenger side airbag cushion comprising:

at least a first panel having a central gas opening and at least one vent hole, an additional  
15 panel having dimensions less than or equal to that of the first and being attached along the edge thereof to the first panel in a position covering the at least one vent hole in said first panel,

and at least one tether attached to said first panel to provide for the flow of  
20 gas from the gas opening in said first panel into a primary chamber defined by said first panel, and a secondary chamber defined between said first and additional

panels receives gas from said primary chamber through said at least one vent hole in said first panel.

75. A multiple chamber side impact airbag cushion comprising:

5 a first panel having a central gas opening and at least one vent hole,  
a second panel having substantially the same dimensions as the first panel, having at least one vent opening spaced from the center thereof, and being attached to the first panel, along the edge thereof,

10 a third panel having dimensions less than or equal to that of the second panel, having no vent openings therein, and being attached along the edge thereof to the second panel in a position covering the at least one vent opening in said second panel,

15 and wherein gas flows from the gas opening in said first panel into a primary chamber defined between said first and second panels, a and secondary chamber defined between said second and third panels receives gas from said primary chamber through said at least one vent opening in said second panel.

20 76. The multiple chamber driver side airbag cushion of Claim 73, wherein the primary chamber expands upon inflation to a distance of about 350 mm inches or less from the steering column toward the vehicle occupant.

77. The multiple chamber driver side airbag cushion of Claim 76, wherein the secondary chamber expands upon inflation to a distance of 100 mm or less from the second panel toward a vehicle occupant.

5 78. The multiple chamber airbag cushion of claim 21, wherein the final venting of gas from the inflated secondary chamber is back through the primary chamber and out said at least one vent hole in said first panel.

79. The multiple chamber airbag cushion of claim 21, wherein said  
10 airbag cushion is adapted to be used with a two stage gas inflator.

80. The multiple chamber airbag cushion of claim 21, wherein the  
multiple chamber airbag cushion provides a softer landing and reduced rebound for the  
occupant as compared to a single chamber tethered airbag.

15 81. The multiple chamber airbag cushion of claim 21, wherein the multiple chamber airbag cushion provides a shorter maximum excursion of the primary chamber as compared to the maximum excursion of a single chamber tethered airbag.

20 82. The multiple chamber airbag cushion of claim 21, wherein said primary chamber reaches maximum pressure much faster than a single chamber tethered airbag.



83. The multiple chamber airbag cushion of claim 82, wherein said primary chamber reaches maximum pressure in about 40 ms or less.

84. The multiple chamber airbag cushion of claim 21, wherein said secondary chamber only reaches partial inflation when the primary chamber has reached maximum inflation.

85. The multiple chamber airbag cushion of claim 21, wherein the rebound distance of a drop test of the fully inflated multiple chamber airbag cushion is at least about 10% less than that of a single chamber tethered airbag.

86. The multiple chamber airbag cushion of claim 85, wherein the rebound distance is at least about 20% less.

87. The multiple chamber airbag cushion of claim 85, wherein the rebound distant is at least about 70% less.

88. The multiple chamber airbag cushion of claim 85, wherein the rebound distance is at least about 75% less.

89. The multiple chamber airbag cushion of claim 21, wherein the effective tether length is about 500 mm or less.

90. The multiple chamber airbag cushion of claim 89, wherein the effective tether length is about 400 mm or less.

91. The multiple chamber airbag cushion of claim 90, wherein the effective tether  
5 length is about 300 mm or less.

92. The multiple chamber airbag cushion of claim 91, wherein the effective tether length is about 160 mm or less.

10 93. The multiple chamber airbag cushion of claim 21, wherein the rebound distance of the multiple chamber airbag cushion is at least about 10% or less than that of a single chamber tethered airbag.

15 94. The multiple chamber airbag cushion of claim 21, wherein the peak deceleration (a measure of the force experienced by the occupant) of the multiple chamber airbag cushion is about 10% less than that of a single chamber tethered airbag.

20 95. The multiple chamber airbag cushion of claim 21, wherein the impact force on an object rested at a first position as measured by object movement of the multiple chamber airbag cushion is less than that of a single chamber tethered airbag.

96. The multiple chamber airbag cushion of claim 95, wherein the object movement is at least about 10% less than that of the single chamber tethered airbag.

97. The multiple chamber airbag cushion of claim 95, wherein the object  
5 movement is at least about 20% less.

98. The multiple chamber airbag cushion of claim 95, wherein the object movement is at least about 30 % less.

99. The multiple chamber airbag cushion of claim 95, wherein the object  
10 movement is less than 5 inches at a distance of 10 inches.

100. The multiple chamber airbag cushion of claim 21, wherein the multiple  
15 chamber airbag cushion provides enhanced protection for an out-of-position occupant.

101. The multiple chamber airbag cushion of claim 21, wherein the multiple chamber airbag cushion provides enhanced protection for an occupant sitting too close to the airbag during deployment.

20 102. The multiple chamber airbag cushion of claim 21, wherein the volume of the secondary chamber is less than about 15 liters.

103. The multiple chamber airbag cushion of claim 21, wherein the tether length is about 160 – 180 mm.

104. The multiple chamber airbag cushion of claim 21, further comprising at least one secondary tether for tethering the third panel to the second panel and located within the secondary chamber.

105. The multiple chamber airbag cushion of claim 21, further comprising a fourth vented panel between said second and third panels and attached to said second panel to form a tertiary chamber between said primary and secondary chambers and serving as a gas flow modulator.

106. The multiple chamber passenger side airbag cushion of claim 105, wherein said fourth panel is sewn on at least one of the inside and outside surface of said second panel.

107. The multiple chamber airbag cushion of claim 21, wherein said at least one vent hole in said first panel is larger than the effective vent size of said vent openings in said second panel between said primary and secondary chambers.

108. The multiple chamber airbag cushion of claim 21, wherein the vehicle restraint system sense a smaller occupant will be in contact with the deploying multiple

chamber airbag (OOPO) and the firing of the second stage of the inflator is delayed, the secondary chamber will not fully inflate during the punch out phase.

109. The multiple chamber airbag cushion of claim 21, wherein when the vehicle  
5 restraint system senses a larger occupant and both stages of the inflator are fired, then the primary and secondary chambers will inflate.

110. The airbag cushion of claim 21, wherein the secondary chamber is divided  
into a respective head and chest chambers to control vicious criteria.

111. The multiple chamber airbag cushion of claim 21, wherein the airbag cushion  
includes a tertiary chamber formed by a forth panel attached to said second panel beside  
the third panel.

15 112. The multiple chamber airbag cushion of claim 111, wherein the secondary  
and tertiary chambers form respective head and chest chambers to control vicious criteria.

113. The multiple chamber airbag cushion of claim 111, wherein the third and  
fourth panels are sewn to the outside of the second panel.

20 114. The multiple chamber airbag cushion of claim 111, wherein the third and  
fourth panels are sewn to the inside of the second panel.

115. The multiple chamber airbag cushion of claim 111, wherein the first, second, and third panels are woven as a single item.

5 116. A multiple chamber airbag cushion comprising:

a first panel having a central gas opening and at least one vent hole,

a second panel having substantially the same dimensions as the first panel,

and being attached to the first panel, along the edge thereof,

10 a third panel having dimensions less than or equal to that of the second panel, and being attached along the edge thereof to the second panel with at least one of the second and third panels covering at least one vent opening in the other of said panels, a secondary chamber defined between said second and third panels receives gas from said primary chamber through said at least one vent opening in at least one of said second and third panels.

15 117. A multiple chamber airbag cushion comprising:

a first panel having a central gas opening and at least one vent hole,

a second panel having substantially the same dimensions as the first panel, having at least one vent opening spaced from the center thereof, and being attached to the first panel, along the edge thereof,

20 a third panel having dimensions less than or equal to that of the second panel, having no vent openings therein, and being attached along the edge thereof

to the second panel in a position covering the at least one vent opening in said second panel,

and rip stitches attached between said first and second panels, and wherein gas flows from the gas opening in said first panel into a primary chamber defined between said first and second panels, and a secondary chamber defined between said second and third panels receives gas from said primary chamber through said at least one vent opening in said second panel.

118. A multiple chamber airbag cushion comprising:

a first panel having a central gas opening and at least one vent hole,

a second panel having substantially the same dimensions as the first panel,

and being attached to the first panel, along the edge thereof,

a third panel having dimensions less than or equal to that of the second panel, having at least one vent opening therein, and being attached along the edge thereof

to the second panel in a position between said first and second panels, and at least one tether attached between said first and third panels near the center thereof and having a plurality of vent openings in the sides thereof to provide for the flow of gas from the gas opening in said first panel into a primary chamber defined between said first and third panels, a secondary chamber defined between said second and third panels receives gas

from said primary chamber through said at least one vent opening in said third panel.

119. The multiple chamber airbag cushion of claim 21, wherein the panels are attached one to another by at least one of sewing, stitching, gluing, welding, sealing, and combinations thereof.

5           120. The multiple chamber airbag cushion of claim 21, wherein the tether is attached by an octagon stitch.

10           121. The multiple chamber airbag cushion of claim 21, wherein the fabric utilization is optimized by cutting two tether pieces at a 45° bias to the warp and fill and the other two tether pieces at 90°.

122. In a module for a vehicle restraint system, the improvement comprising the multiple chamber airbag cushion of claim 21.

15           123. A multiple chamber passenger side airbag cushion comprising at least two body panels, a first large front panel adapted to be attached to said body panels to form a primary chamber, and a second smaller front panel adapted to be attached to said first large panel to form a secondary chamber there between, said large front panel having at least one vent opening therein for gas to fill the secondary chamber during inflation.

20           124. The multiple chamber passenger side airbag cushion of claim 123, wherein said body panels are at least one of kidney shaped and polygonal.



125. The multiple chamber passenger side airbag cushion of claim 123, further comprising an additional panel adapted to be attached to said first large front panel and form a chamber there between.

5 126. A multiple chamber airbag cushion comprising:

- a first panel having a central gas opening and at least one vent hole,
- a second panel having substantially the same dimensions as the first panel,
- and being attached to the first panel, along the edge thereof,

a third panel having dimensions less than or equal to that of the second panel, being  
10 attached along the edge thereof to the second panel, and being made of a gas permeable fabric, a secondary chamber defined between said second and third panels receives gas from said primary chamber through said gas permeable fabric.

127. A multiple chamber airbag cushion comprising:

- 15 a first panel having a central gas opening and at least one vent hole,
- a second panel having substantially the same dimensions as the first panel,
- and being attached to the first panel, along the edge thereof,

a third panel having dimensions less than or equal to that of the second panel, and being  
attached along the edge thereof, said second panel being made of a gas permeable fabric a  
20 secondary chamber defined between said second and third panels receives gas from said primary chamber through said panel.

128. A multiple chamber airbag cushion comprising:

a first panel having a central gas opening,

a second panel having substantially the same dimensions as the first panel,

and being attached to the first panel, along the edge thereof, to define a primary

5 chamber therein

a third panel having dimensions less than or equal to that of the second panel, and being  
attached along the edge thereof to the second panel, and at least one of said first, second,  
and third panels being made of a gas permeable fabric.

10 129. The airbag cushion of claim 128, wherein said first panel is made of gas  
permeable fabric.

130. The airbag cushion of claim 129, wherein at least one of said second and  
third panels are made of gas permeable fabric.